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THE "DIOSCURES" TWIN SATELLITES RECOMMENDED BY CNES AND SGAC FOR AERIAL NAVIGATION

by Jean-Claude Trichet

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ABSTRACT. This article describes the purpose, technique and financing of the French "Dioscures" twin-satellite project, to be used mainly over the North Atlantic, for locating airplanes. The author voices some criticism of Comsat's attitude towards the project and stresses the importance of "Dioscures" for European cooperation based on French initiative.

Several studies are in course at present concerning the utilization of satellites for locating airplanes over the North Atlantic and especially to comply with needs arising from the expansion of commercial aviation. France, however, went beyond a general survey of such a system. Cooperating for about two years, the National Center for Special Studies and the General Secretariat for Civilian Aviation prepared the "Dioscures" project. On page 29 of this issue, we describe the characteristics and possibilities of the project.

The Twins and Their Affiliation

The two strictly identical satellites will provide communication relays between airplanes and ground stations; but their main purpose is the location of airplanes. The method for locating airplanes (measurement of radio signal propagation time) is based on results obtained with project "Eole". Let us recall that this project involves the utilization of a satellite for locating meteorological balloons drifting at high altitudes. The definition of the satellites derives from the telecommunication satellite project "Saros" which has now been substituted by the Franco-German project "Symphonie". Two satellite projects have been drafted: one involves gyroscopic stabilization only, provided with mechanic and electronic antennas rotating counter-clockwise; another geocentric project involves semi-active stabilization by rotor inertia and magnetic coil. This position of the two satellites will be in the longitude of 10° and 60° East. Each satellite will carry:

- A position finder of 1,600 MHz with a power output of 5 W.

- A communication system (telecommunication) of 1,600 MHz, with a power output of 20 W.

- A position finder of 4,000 MHz, with a power output of 0.5 W.

- A communication system (transmitter of data) of 4,000 MHz, with a power output of 1 W.

This requires an electric generating plant providing 95 W power during the service life of the satellite, i.e., 105 W at the start, with a degradation of 10% during the lifespan of three years scheduled for the satellites. The solar generator needed to provide this power, for a satellite stabilized through rotation, would include 14,400 cells distributed on the 8 faces of the satellite. Its weight would be 17 kg; together with its aluminum honeycomb support. After landing and during periods around the equinox, the batteries would be rapidly recharged. An auxiliary solar generator has been foreseen for this purpose, consisting of cells in their layers, less than 200 microns thick, fastened to the two faces of the antenna. The generator would provide 230 watt-hours per orbit; this would be amply sufficient for recharging the battery which should not use more than 130 W during the 70 minute equinox eclipse. The mass of the satellites (160 kg for the gyroscopic type and 167 for the geocentric type) depends on the mass of the structure. The volume of satellites is determined by the dimensions of the apogee engine and of the stabilization equipment.

Followed by Laser at a Distance of 10 Meters

The ~~two~~ geostationary satellites are spaced by 50° longitude. Their latitude position can be maintained at nearly 1/4°, with a correction approximately every 100th day. Longitude position is guaranteed at nearly 1°, with a correction approximately every 20th day.

To locate airplanes with global precision, it is necessary to know the exact position of each satellite. A satellite with a strictly zero orbit trajectory inclination and with a longitudinal drift of 0.05 degrees per day will displace itself by 100 meters from its orbit in 3.9 minutes. Accordingly, a day-by-day tracing of the satellites is required so as to foresee what their position would be during the next 24 hours. Instead of using the radio-electric tracing system customary today, CNES preferred (for the moment) the spatial telemetric system by laser, which has been studied, on the basis of installations actually used within the scope of the "Diademe" program. The system, with a precision within 10 meters, will use stations the cost of which should not be over and above one million Francs. The satellites will be provided with reflectors consisting of solid or hollow pyramids. The full reflector would be built of borosilicate; it will be shielded against radiation by a caesium layer.

These satellites can be orbited with an Europa-Pas launcher.

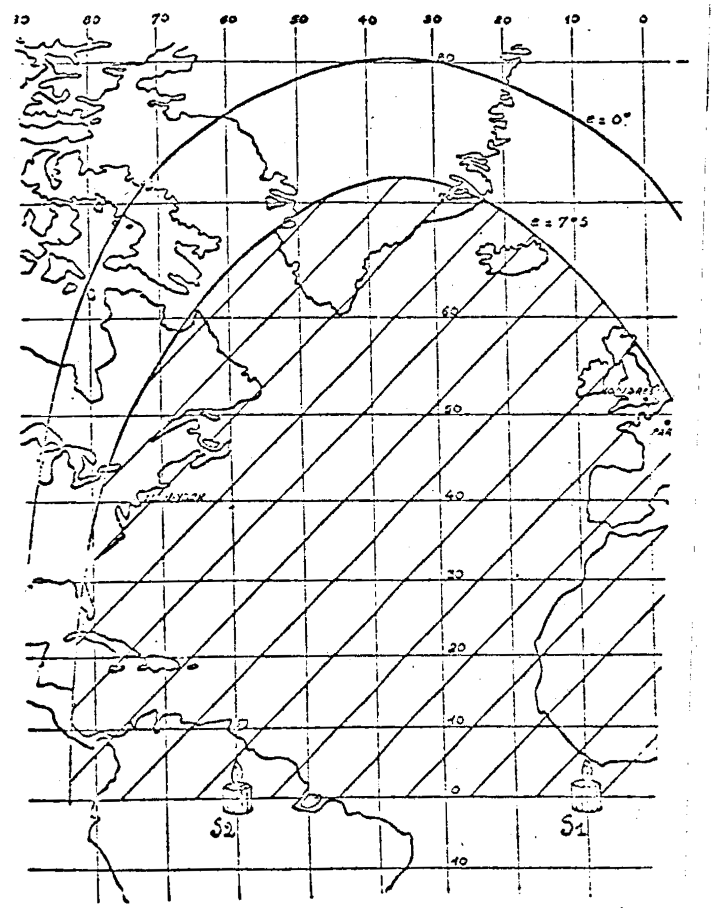

Figure 1. North Atlantic range covered by the two satellites. The chart shows lines indicating the limits, (corresponding to optical axles 0" and 7.5") within which the airplane sees the satellite above the horizon. It is noteworthy that the South Atlantic range is symmetrically covered. This represents more than 90% of the aerial lines of the American, European and African continents.

The Financing Problem

How can the program be financed and which agency could undertake the administration of the system? Since this is a system for international use, the reply to the above questions will require lengthy negotiations. It was to be expected that Comsat's voice would be heard. Comsat contacted Intelstat to suggest that a commission be set up to study these problems. Comsat suggests the utilization of multiple-function satellites for aerial navigation, which satellites were recommended for the Intelstat IV network. First, this involves certain technical problems regarding the definition of a position-finding system. The simplest and most appropriate technique involves the measurement of propagation time; two satellites are needed to cover a zone with this method. If a single satellite is to be used, the interferometric technique in conjunction with distance measurement must be applied. This system involves tremendous technological problems. Finally: numerous specialists contend that a multiple-use satellite would have to be very heavy. Multiple use, involves many possible causes for breakdowns. A system which serves multiple purposes simultaneously (television transmission, telephone lines and transmission for aerial navigation) would certainly be unfavorable for the companies. It is absolutely necessary to install an antenna on airplanes which corresponds to ground station antennas. According to rules presently applicable to telecommunication satellites, airplane-satellite transmission is estimated costlier than the ground station satellite transmission. For the "Dioscures" project, the ammortization cost of the system (satellites and ground stations) would be 550 Francs per orbit, for the very realistically scheduled 3-year lifespan of the satellites, involving a traffic of 600 airplanes per day. The ammortization of the airplane equipment would amount to 450 Francs for each orbit.

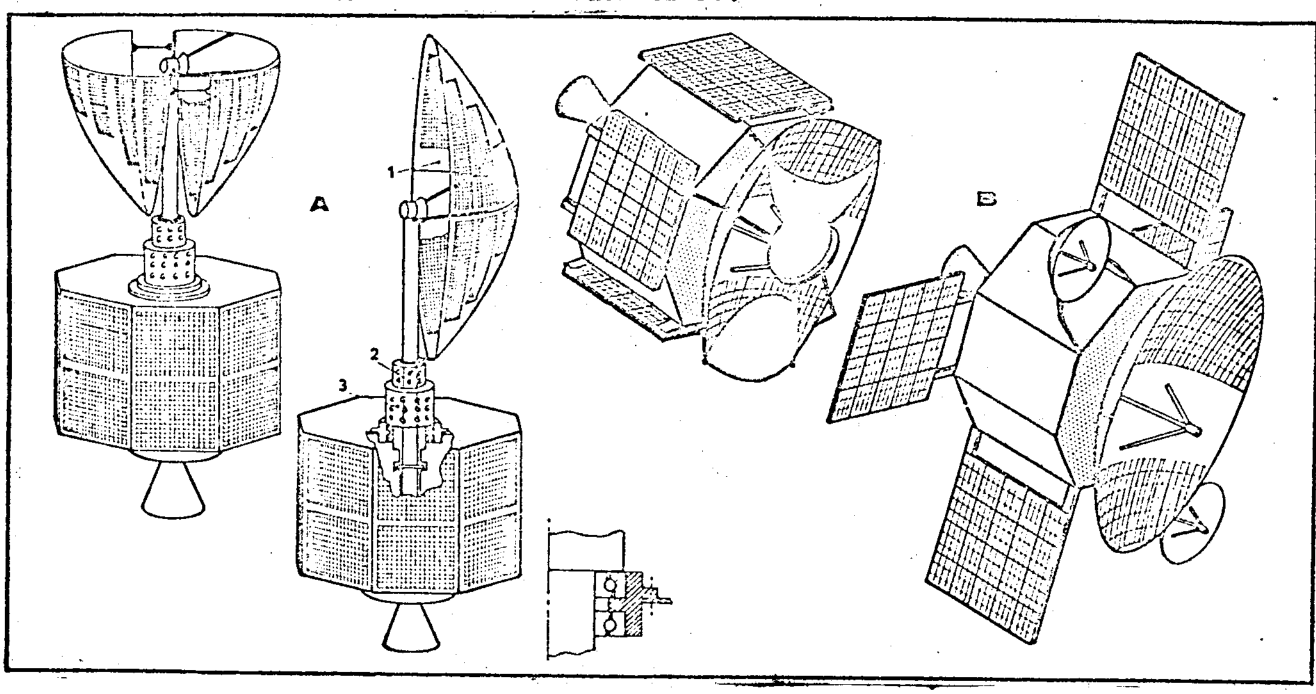

Figure 2. Each type of satellite is represented, folded (at left) and in operational position (at right). A) Gyroscopic satellite. Foldable antenna (1), covered with solar cells in thin layers (auxiliary generator) with an output of 24 dB at 1,600 MHz. The antenna is mounted on roller-bearings. The satellite turns around its axle and the antenna maintains communications with the airplanes. The 6,000 MHz (2) and 4,000 MHz (3) antennas maintain ground communications. They rotate counter-clockwise electronically. B) Geocentric satellite. The large antenna for communicating with airplanes is partially foldable. It is oriented towards the center of the Earth. The antenna is covered with thin layers of solar cells for the auxiliary generator. Ground communications are relayed by the two small lateral antennas.

The users are primarily interested in a system serving their own needs. The administration of which they could control. The users are not only airway companies, but also agencies responsible for airway traffic in the combines concerned. As for the navigation over the North Atlantic: it should be noted that 52% of the traffic in this region is implemented by the airplanes of European and Eastern countries.

This is another factor which maybe explains the maneuvers of ComSat: a multiple-use satellite would weigh at least 500 kg. At variance from the Dioscures, it would be imperative to use an American launcher for orbiting it. On the other hand - as shown - the French project foresees techniques which are already quite well known. Lengthy studies would probably be needed for developing a multiple-use satellite, or American industry would have to be approved.

CNES and SGAC have to be commended for having shown that a pioneer spirit still exists on this side of the Atlantic; it goes hand in hand with a unanimously recognized need. The work of CNES and SGAC is beyond the stage of general debate. They demonstrated that such a program is within the reach of our industry. Financially, it is available for Europe - the Continent principally interested in the North Atlantic. Politically, Great Britain's standpoint will be of foremost importance: Britain will have to make a choice between giving in to American pressure and supporting a project which could, from a merely French level, evolve towards European cooperation.

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